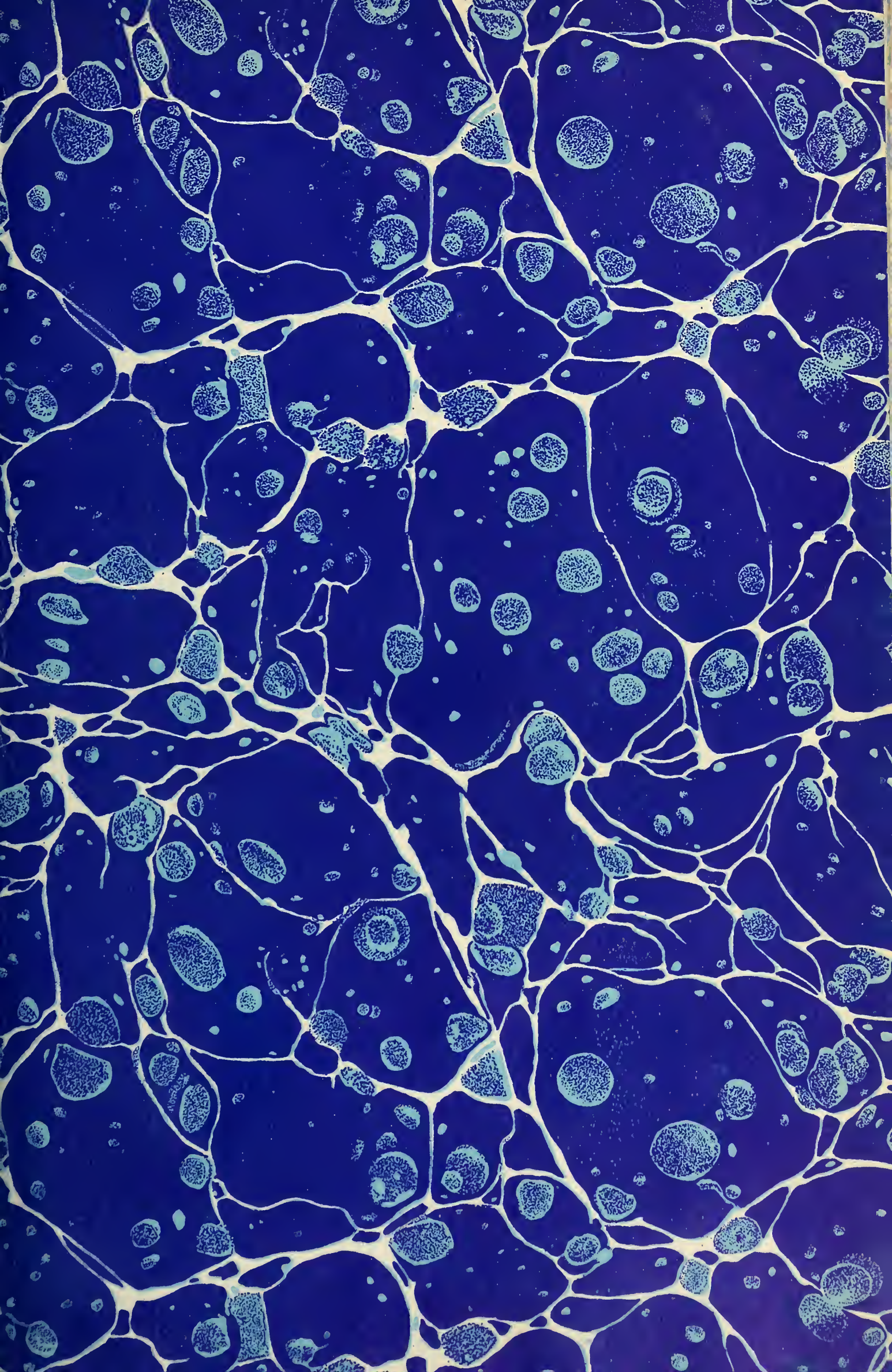

Issued July 10, 1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

REPORT OF

THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1914.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., February 15, 1915.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1914.

Respectfully,

D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1914.

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

Porto Rico, with an area of 3,600 square miles, has a population of over 1,000,000. The population is increasing, as is likewise the agricultural production. There is but little increase in manufactures and it is not probable that the island is destined to become a manufacturing country, as there is no coal and but little water power. The population is largely rural, and with present desires and training will remain so.

During the year 1914 the agricultural interests have faced several crises. The reduction of the duty on sugar has seriously affected the leading industry and has been greatly felt in all lines of business. Again, the European war has hit hard the coffee growers, as the crop is largely sold abroad. Fruit shipped to the United States has sold lower than at any time since the establishment of the industry in Porto Rico. As a result of present conditions, both exports and imports have decreased.

In order to somewhat relieve the situation a more thorough study of the soils should be made, with a view to increasing their productiveness, and there should be more diversification of crops. There should be more and better live stock on the farms to improve the living condition of the planters, as well as to yield an additional income.

NATURAL RESOURCES AND CONDITIONS.

Porto Rico is an old-settled country. Permanent settlements were made here before they were in the mainland of North America. Moreover, the island is and has been for many years thickly populated. It is not strange, therefore, that the natural resources of the country have been thoroughly exploited. The forests have been consumed, and, with charcoal as the fuel used for cooking, reforestation has made no headway. The fertility of the soil, the greatest natural resource of a country, has been very largely depleted by an unscientific agriculture. The agriculture needed, therefore, is necessarily a constructive one.

As the products come primarily from the soil, it is to the soil that the highest skill should be applied. Contrary to general belief, tropical soils are not naturally fertile. It is true that in virgin forests, where humus deposits have accumulated for many years, they are quite productive, but that fertility must be very carefully conserved or it will be lost, and that, too, not by cropping. Denuded of trees, tropical upland soils soon lose their fertility by the washing and leaching of rains and the action of the burning sun. Where covered with forests, especially of leguminous trees, they are productive for coffee, cacao, etc., but when bare they become hard and compact, not holding moisture and producing only scant, unprofitable grasses. It is a slow and tedious process to bring these lands back to the production of profitable crops or trees.

It is true that the growing season in the Tropics is 12 months of the year, yet the quick growth of vegetables known in the north in the spring is not obtained in the Tropics. Persons from the temperate zones, seeing the misery among many of the rural population, ascribe the condition to shiftlessness, while in the main it is due to ignorance. The natural conditions are such that the small planter can not get the immediate results with salable crops that are obtained in the spring season in the north.

What is the cause of this? In northern climates the freezing of winter puts the soil in a favorable condition or releases plant food therein, producing conditions for rapid spring growth. In the Tropics these favorable conditions do not exist, and plants which require a long period of growth are the most successful. The use of fertilizers becomes more necessary.

In Porto Rico the level lowlands are by far the most productive. The great problem in connection with these soils is one of rotation. At present they are largely devoted to sugar cane, but natural conditions have already compelled the adoption of rotations, and this will be accelerated by reason of change in economic conditions and the consequent lowering in the price of sugar. Doubtless many of the cane lands will go into grass, with a resulting increased production of live stock.

The hill lands offer a more serious problem. Those that have not been stripped of their forests have been largely planted to coffee and fruit trees, which, growing beneath certain leguminous trees, are protected from the fierce rays of the sun and the force of the wind, and aid in conserving the moisture. Moreover, the leguminous nurse trees store nitrogen in the soil, which serves to nourish the economic trees of lesser height growing under them. Hill lands that have been denuded of their forests produce only sparse grasses, affording but little sustenance to horses and cattle. To bring them back to profitable production requires time, skill, and capital. When the

timber is cut from such lands they are robbed of almost their entire value. They soon lose their humus, and fertilizers applied give but meager results. Leguminous plants are needed to improve such lands, and, fortunately, there are a number available. These range from the native beggar weed, sensitive plant, and the wild peanut, trailing along the ground, to the cowpea and velvet bean of larger growth and high feeding value. Of leguminous trees the guamá (*Inga laurina*) and guava (*Inga vera*) have long been used, while some other lesser known and introduced kinds have a high value in reclaiming barren hills and bringing them again into cultivation. In the Tropics, where there is no frost, the soil should be covered with vegetation at all times. In this way the fertility is best conserved. When a direct money crop is not growing there should be legumes.

REFORESTING.

Porto Rico is situated in the Tropics and at the door of the eastern seaboard of the United States—the best market in the world. Intensive farming therefore should be practiced. Tree products will prove the most prolific per area and orchard products will doubtless prove to be the leading ones. In order to get the lands planted to fruits, coffee, and nuts, leguminous trees are generally considered the best nurse crops.

The station has 200 acres of hill land on a mountain above Mayaguez. This has been cut over for a number of years and the soil is badly gullied. An experiment in reforesting this area is under way, and about 120 acres have been planted to leguminous and hardwood trees. Among the legumes, the guamá (*Inga laurina*) and the cojoba (*Copaifera hymenæifolia*) are the more promising at this time. The indications are that mahogany will do well, and as a fruit tree the mango is proving valuable for planting in such situations.

In reforesting the island, leguminous trees should have first consideration, as they improve the soil and serve as nurse trees for all others. As trees that will do best without nurse trees, from trials of a great many, the eucalyptus, mahogany, and mango are the most promising. The swamp mahogany (*Eucalyptus robusta*) is the best of that genus. Only the improved varieties of mangoes should be planted, as the common sorts are of little economic value.

GUANO DEPOSITS.

One natural resource of Porto Rico that has been utilized to but a small extent is the bat guano deposited in the caves of the island. The station has begun a survey of these deposits and is estimating their extent and value. Some samples run quite high in phosphoric acid

and have a measurable percentage of nitrogen. The more accessible caves, no doubt, will yield a more economical fertilizer than that now imported, and reduce somewhat the amount of money sent abroad for this product.

LIVE STOCK.

The horse stock on the island has been much improved in the last eight years, mainly by the use of purebred sires. The station has imported 8—5 saddle bred, 2 thoroughbred, and 1 Morgan. Several additional ones have been imported by planters. The types best suited to crossing with native stock are the lighter breeds, thoroughbred, trotting, and saddle horses.

The most successful sections for horse breeding are the limestone regions of the south side of the island, where Guinea grass flourishes at its best.

Cattle raising is again becoming important, especially as the sugar situation is compelling many of our planters to consider rotations in the use of cane lands.

There have been many importations of cattle, with varying success. The great drawback is the cattle tick, which not only causes losses from tick fever but increases the cost of production. No animal can thrive on a minimum amount of feed when it acts as host to a large number of voracious blood-sucking insects. Before cattle growing can reach the highest success the tick must be eradicated. As cattle are used largely for draft purposes a campaign for tick eradication must have not only the cooperation of the planters but of those engaged in transportation as well. Considerable time and expense will be required in exterminating the tick from the island, and it will be necessary to have an aroused public sentiment back of the work to insure its success. No expenditure of a like sum promises such large results to the people of Porto Rico as the eradication of the cattle tick.

Two years ago an epidemic disease among swine swept over the island and caused large losses. The station herd was entirely wiped out. The disease seems to have ceased and hog raising is again increasing. Such animals are easily grown here, and there are a variety of plants and waste products that furnish food for them.

There is a marked improvement in poultry everywhere, and the heavier breeds are becoming quite common where a few years ago only the small game chicken was found. The production of poultry on a large scale has proven profitable in several instances and poultry raising among the small farmers and agricultural laborers is becoming more general. Poultry products are relatively high in price and are in constant demand. They afford the first incentive

to the peon classes to improve their condition by producing and offering for sale something besides unskilled labor, which is nearly always in excess of the demand in Porto Rico.

FORAGE AND COVER CROPS.

Among recent introductions two crops rank high in value to the island: Velvet beans (*Stizolobium* spp.), rank-growing legumes, are of value as green manure and also stand high as feed for stock. The sword bean (*Canavalia* sp.) has been widely distributed by the station, and is now quite generally grown in the citrus orchards as a cover crop. The velvet bean is supplanting the sword bean, as it gives a larger growth and also affords good feed for horses, cattle, and pigs.

Sudan grass won instant popularity, especially in the dry sections of the island. It makes a wonderful growth with a minimum rainfall and is well relished by live stock. It is easily grown from seed and, as it is a bunch grass, it is not likely to prove a pest. In regions of abundant rainfall it makes a rank growth, but it is difficult to obtain seed, due to a fungus attack of the head.

FIBER CROPS.

The station, in cooperation with the insular government, planted 75 acres of dry land on the south coast to sisal and henequen. The growth has been slow and the results have not been such as to induce private capital to take over the enterprise and extend it. As the machinery necessary for the successful extraction of this fiber costs several thousand dollars, it would require a large and successful planting to justify the expenditure. As the lands in Porto Rico are mainly in small holdings and the value much above that of lands in other countries where this fiber is produced, it does not seem promising unless efficient and less expensive machinery can be devised that will justify its exploitation on a smaller scale.

Carludovica palmata, used in making the Panama hat, was introduced by the station several years ago, and it has been widely distributed and seems destined to supplant the native palm (palma de cogollo) now used for this purpose in Porto Rico. It not only makes a better and more valuable hat but is easier to weave. As the exports of hats during the year amounted to $262,364, the importance of the improved strain to our weaving industry can be readily seen.

RURAL CREDITS.

In the matter of the planter securing money for either long or short loans there are two serious drawbacks in Porto Rico. One is the high cost, 12 per cent per annum being the usual rate, and the

other is the cumbersome and expensive title and recording regulations. The notary and stamp fees in the ordinary transactions in land are so excessive as to almost prohibit the small landholder from securing money on his property. Some simpler method, as the Torrens system, would reduce the cost of making out the necessary papers, and also, by simplifying such transactions and quieting titles, reduce the rates of interest.

COOPERATION AND MARKETING.

Cooperation continues among the cane growers, especially in looking after legal matters affecting the industry. The fruit growers maintain an efficient organization, with an office in New York for marketing their products. They also cooperate in the buying of supplies, such as crates, fertilizers, etc. This organization is growing and doing much good. The tobacco growers have an organization. The coffee growers have an organization, but it has not made much progress. Their efforts have been directed toward marketing their product in the States instead of in Europe. The association lacks cohesion and the backing of the coffee growers.

IMPROVEMENTS AND EXTENSION.

The station during the year has erected, under an appropriation of the insular government of $6,000, a plant house, and has remodeled the old sugar-mill building that in the beginning housed the office and laboratories. The plant house is 88 by 124 feet, partly covered with glass and partly with wire netting. An additional weighing room, 30 by 15 feet, made of cement and covered by tile, was constructed. This house is equipped with cars and tracks, on which pots are mounted for soil and plant studies. (See Pl. I, figs. 1 and 2.)

The old sugar-mill building, 29 by 196 feet, had the south wall torn out and rebuilt and was covered with a tile roof. It is used for the storage of heavy chemicals, apparatus, and hand machinery.

The improvement of the station grounds was continued, wooden culverts, fence posts, etc., being replaced with cement structures.

The distribution of seeds, plants, and cuttings has been larger than in any previous year. This includes valuable importations which have been tested at the station and others of local origin and improvement.

The correspondence and field work of the station staff continues to expand. This work is of such amount as to hamper the research work of the station, yet its importance calls for more effort along these lines. Provision for extension work in Porto Rico would, it is believed, be of material assistance to the planters and serve the important purpose of bringing the results of research directly to their attention—a matter very much to be desired.

FIG. 1.—EXTERIOR VIEW OF NEW PLANT HOUSE.

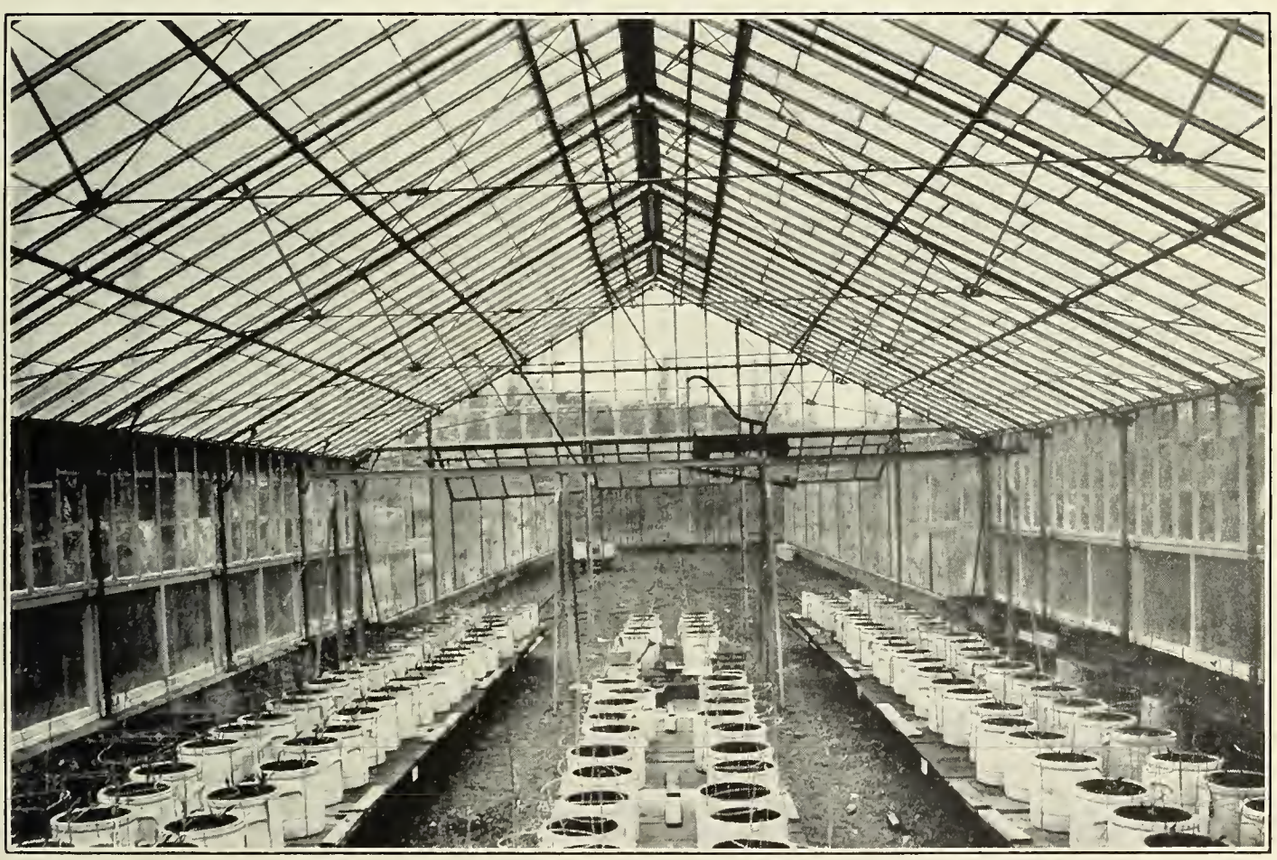

FIG. 2.—INTERIOR VIEW OF NEW PLANT HOUSE.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

INTRODUCTION.

The work the past year was continued along the lines noted in the previous report. Progress in several investigations requiring quantitative vegetative experiments was considerably furthered by use of the new plant house. The equipment for carrying on vegetative experiments in pots, which was completed in August, comprises a small house for mixing soil, preparing pots, and drying samples; a glass house, with a weighing device, for protection of the plants during heavy rains; and a wire rat-proof inclosure, where the pots are kept during favorable weather. The houses and inclosure carry tracks and trucks sufficient for about 200 large pots. (Pl. I, figs. 1 and 2.)

ANALYTICAL WORK.

The analysis of some 50 plant ashes, in connection with the investigations detailed below, formed the chief part of the analytical work for 1914. Various samples of lime, fertilizers, guanos, molasses, water, and miscellaneous materials were also analyzed.

In the course of the work with plant ashes the permanganate method for determining iron was compared with the potassium sulphocyanate colorimetric method. The colorimetric method was found preferable for the determination of the small amounts of iron contained in most plant substances. Duplicate results obtained by this method checked very closely, while duplicate samples, run by the permanganate method at different times, occasionally varied considerably. The colorimetric method gave lower results than the permanganate method, particularly when the quantity of iron determined was very small, viz, only a few milligrams or tenths of a milligram. With fairly large quantities of iron the two methods agreed, as was expected.

In determining a milligram of iron with a fortieth-normal solution of permanganate, the quantity of permanganate required for oxidation is so small that a slight difference in reading the burette makes a large percentage difference in the result. The colorimetric method is also more rapid, in that repeated evaporations with sulphuric acid to expel chlorids and subsequent reduction with zinc are unnecessary.

FERTILIZER EXPERIMENTS ON THE RED CLAY SOIL.

The fertilizer plats with sugar cane which were laid out in the Anasco Valley in 1913 were cut in April, 1914. The soil was slightly different from the ordinary red clay soil, but was more nearly related to this type than any other. The detailed results of this experiment, which comprised 73 plats of half an acre each, will be published with those of other tests at a later date. The results showed, however, that lime, nitrate of soda, sulphate of ammonia, dried blood, a nitrogenous and phosphatic fertilizer, and a complete fertilizer all failed to increase appreciably the yield of cane on this soil.

It had been previously observed that liming and nitrogenous fertilizers increased considerably the productivity of some of the red clay soil for sugar cane. This experiment, which was designed to measure on a larger scale the increases produced by those materials, merely emphasizes the fact, already pointed out, that all the red clay soil does not respond to fertilizer.

Three more series of tenth-acre plats, embracing some 225 plats in all, were laid off on different fields of red clay soil in the Anasco Valley last year. On two fields the plats were planned to show the response of this soil to nitrogen, phosphoric acid, and potash, used singly and in combinations furnishing two elements and all three elements. All the fertilizers were applied on the basis of 50 pounds of each element per acre—i. e., sufficient fertilizer to furnish 50 pounds of nitrogen, 50 pounds of potash, etc. Sulphate of ammonia, double superphosphate, and high-grade muriate of potash were used.

The third series of plats was devoted to a comparison of the effectiveness of four different nitrogenous fertilizers on this soil. Nitrate of soda, cyanamid, and tankage were compared with sulphate of ammonia. All plats in this series received a heavy application of potash and phosphoric acid. In addition, sulphate of ammonia was applied at the rate of 20, 35, and 60 pounds of nitrogen per acre, while the nitrate of soda, cyanamid, and tankage were all applied at the rate of 35 pounds of nitrogen per acre. The cane on these plats will be cut in the early part of 1915.

The experimental plats are all located on the property of Guanica Central and the fertilizers employed were furnished by the company.

CHLOROSIS OF SUGAR CANE.

The second series of plats at Central Cortado, which were designed to measure the effect of ferrous sulphate and stable manure on the development of chlorotic cane, were cut in January, 1914. The ferrous sulphate and stable manure were applied in smaller amounts on these plats than on the former series, to see whether a moderate money value of these materials would produce a profitable increase in the

tonnage of cane. There were 20 plats, of one-fourth acre each, with four different treatments, so that each plat was replicated five times. The results seem to show that small applications of these materials have but little effect on the cane. The heavier applications in the former series of plats seemed to produce quite notable increases in tonnage but at a prohibitive cost.

The American Steel & Wire Co. kindly furnished the sulphate of iron for these experiments and the Santa Isabel Sugar Co. the facilities for carrying on the work.

Analyses have been made of several samples of chlorotic and green cane leaves. This work will be continued the coming year, as a considerable number of samples must be examined before any conclusions can be drawn.

It is rather difficult to study the chlorosis of sugar cane by direct experiments, as experiments in pots can not very well be carried on with this crop.

LIME-INDUCED CHLOROSIS.

The work on this subject has been confined to experiments with rice, since this plant is practically as sensitive as the pineapple to carbonate of lime, and is well adapted for growth in pot cultures and nutrient solutions.

From work already reported [1] it appears that at least one action of the carbonate of lime in inducing the chlorosis lies in depressing the assimilation of iron. An attempt is being made to determine whether this is the sole action of the lime or whether it is more complex. A number of experiments have been conducted for this purpose. For the proper interpretation of some of the results obtained, further experiments on related or general subjects were necessary. For instance, when studying the ash composition of green and chlorotic rice plants it was necessary to know how the ash composition of normal rice plants varied at different periods of growth. Accordingly, complete ash analyses were made of the plant at six stages of growth. The results of this particular work are being prepared for publication.

While considerable data has been obtained on the action of carbonate of lime in inducing chlorosis, much work is yet to be done. An experiment was conducted applying ferrous sulphate to the soil and leaves of chlorotic rice grown in calcareous soils. The results were similar to those obtained in previous work with pineapples.[2] Ferrous sulphate applied to the leaves as a spray restored the green color and induced a normal growth, but applied to the soil was without effect.

Since chlorotic plants contain more lime as well as less iron than normal plants, two experiments have been conducted on the effect of gypsum on the growth and appearance of the plants. An attempt

[1] Porto Rico Sta. Bul. 16. [2] Porto Rico Sta. Bul. 11, p. 32.

was also made to see whether chlorosis could be induced by increasing the lime and diminishing the iron content of the plant without the action of carbonate of lime.

Some work has been done on the effect of the reaction of the soil or nutrient medium in bringing about chlorosis and influencing the assimilation of iron. For this purpose one experiment with soil cultures and two tests in nutrient solutions have been carried out.

With the idea of determining the forms of iron that are available to rice. a number of different organic compounds of iron have been tried in a pot experiment with a normal and calcareous soil. A test with colloidal iron was also conducted in water cultures. The results of this latter test were recently published.[1]

One experiment was tried which promised to give rather direct evidence on the whole subject. The results, however, which were not as conclusive as had been anticipated, brought into question the extent to which plants are able to exercise the power of selective absorption. This is being investigated in nutrient solutions.

BAT GUANOS.

Since the completion of the new plant house considerable progress has been made in determining the fertilizing value of the bat guanos already collected. Now that adequate facilities are available, the work will be prosecuted more rapidly and on a more comprehensive scale.

A survey of the caves has been commenced to determine the location of the principal caves, the approximate quantity of material they contain, and the accessibility of the deposits. Samples of the different classes of material present in each cave are being collected for analysis. The chief types of guanos, as ascertained by chemical analysis, are being tested by vegetation experiments in pots to determine the availability of the nitrogen and phosphoric acid. In connection with the vegetation tests it has been necessary to do some work on the methods of conducting such experiments.

The work accomplished so far shows that these deposits vary greatly in chemical composition, but that there are several more or less well-defined types. The vegetation tests show that the availability of the phosphoric acid also varies greatly.

These deposits appear quite numerous and well distributed over the island. There is probably no doubt but that the deposits can furnish valuable fertilizing material for certain districts of the island. The individual deposits, however, are probably too small and transportation on the island too costly for the guanos to be exploited on any scale commercially.

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[1] U. S. Dept. Agr., Jour. Agr. Research, 3 (1914), No. 3, p. 205.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

INTRODUCTION.

The principal lines of work conducted during the past year include experiments with the following: Mangoes, coconuts, bananas, pineapples, leguminous cover crops, root crops, citrus fruits, eucalyptus trees, and a number of plant introductions. The work has not been confined to the experiment station, but many experiments have been carried on in cooperation with plantation owners. In response to requests from planters and for the purpose of studying various crops and conditions numerous trips have been made to various parts of the island. The demand for cooperative experiments and inspection trips increases from year to year on account of the rapidly growing horticultural interests.

RESULTS WITH MISCELLANEOUS CROPS.

MANGO.

Among the East Indian varieties of fruit, Amini and Cambodiana have been the most promising this year. The fruit of both of these varieties is medium in size, but of excellent texture and flavor. The Amini is handsome and tough skinned and should stand shipping well. The Cambodiana, having a thin, tender, easily broken skin, is suited to home use and should be grown in every Porto Rican fruit garden. Work in propagation and nursery practice has been continued and many nursery trees set in the testing orchard. Over 400 trees, including over 60 imported varieties, are now under cultivation.

ROOT CROPS.

Work with yautias, dasheens, yams, sweet potatoes, etc., is being continued. The experiments include ridge versus level planting, large versus small tubers for planting, distance plantings, fertilizers, and variety tests. In cooperation with planters variety tests of dasheens, yautias, and sweet potatoes have been conducted near San Juan, P. R., on the sandy coastal plains. While all the root crops produce well in the heavy soils at Mayaguez, the first crop of yautias grown on the sandy soils has been unsatisfactory. But few of the varieties proved sufficiently prolific to warrant commercial

cultivation. The dasheens were more promising, though not heavy producers. Some varieties of sweet potatoes have given good returns, while many are not profitable under these conditions. Further experiments will be conducted on this type of soil.

CITRUS FRUITS.

Work with citrus fruits has been along lines of fertilization, testing of various stocks, the introduction of promising varieties, and the planting of an experimental grove. This grove set to grapefruit is situated on rolling upland, such as is usually set in coffee. The work was undertaken to test the effect on grapefuit trees of different degrees of shade and wind protection provided by the old leguminous trees and to determine whether this type of land is suited to grapefruit culture.

CITRUS FERTILIZATION EXPERIMENTS.

The experiments in citrus fertilization undertaken in 1905 in cooperation with citrus growers and the German Kali Works have been concluded and the results prepared for publication.[1] Valuable data have been obtained from these experiments in determining the necessity for fertilization and the most satisfactory sources for nitrogen and potash. An important conclusion reached in this work, and one which is being demonstrated by many growers, is the unquestionable need of citrus trees for fertilizers. In plats where trees were not fertilized the growth was slow and the crop of fruit but 27 per cent of that harvested from plats given a complete fertilizer. Where consistent fertilizer practices were followed good crops of thrifty trees resulted. With few exceptions the fertilization that resulted in the heaviest yields of fruit also produced the largest trees, although the effect of fertilization on the tree was less marked. In the fertilized plats the need of a complete fertilizer is decidedly proven. While the effect of complete and incomplete fertilizers on the wood and leaf growth was not so marked as on the production of fruit, in each plat given an incomplete fertilizer the leaves were smaller, and in most instances had poorer color than where a complete fertilizer was given. The yield of fruit was in every case heavier where complete fertilizer was applied. In one orchard where the number and weight of the fruit harvested was recorded the yield of plats given complete fertilizer showed a gain of 80 per cent over those given incomplete, and in the other 44 per cent. Where nitrogen was omitted from the complete fertilizer the yield was poorer than where either potash or phosphoric acid was omitted. Omitting phosphoric

[1] Porto Rico Sta. Bul. 18.

acid resulted in lighter yields than omitting potash. The results of the experiments indicate that for the red loamy rolling lands on the north side of the island phosphoric acid should be applied as liberally as potash. A formula providing for 3 per cent nitrogen, 12 per cent phosphoric acid, and 12 per cent potash is recommended.

COCONUTS.

The coconut cooperative experiments, including fertilization and culture, reported on the past two years, have been continued and new cultural experiments undertaken in parts of the island where different weather conditions prevail. As this is a profitable crop, and one to which but little experimental attention has been given in Porto Rico, it is the plan to extend the lines of work already undertaken, including fertilization, seed-nut selection, and nursery and orchard culture. In the fertilization experiments started in June, 1912, eight harvests have been made. The number of nuts taken from each tree and the diameter of the nuts from the different plats have been recorded for each harvest. The yield in the plats given complete fertilizer was in excess of that in check plats for the last harvest, although between the complete and incomplete and check plats but little differences have resulted so far. The number of nuts harvested in the experimental field hardly averaged 30 per tree. The average diameter of the nuts was 4.8 inches. As the trees under observation are old palms on sandy beach land, apparently an ideal situation for coconut culture, the results of the harvests show how slowly old palms give returns for fertilizer investment. As the yield per tree is far below what it should be, an early increase is expected in the fertilizer plats.

Aside from the notes on fertilization, valuable data have been recorded regarding the number of nuts harvested from the individual trees. A few trees are bearing over 100 nuts per year, exceptional ones over 140, while a number, which are from all appearance thrifty, are producing annually not more than 10 nuts each, and a few not more than 5 nuts each. As there is a good stand of trees in the experimental plats, and productive and unproductive ones are found growing side by side throughout the field, the importance of seed-nut selection by those contemplating a new grove is plainly shown. In connection with selection work, records are being made showing the constancy in shape and size of both husks and nuts borne by individual trees.

In cooperation with A. J. Harvey, experiments are being conducted on his plantation to determine the advisability of growing leguminous cover crops in a young coconut grove. This plantation is situated a few miles east of San Juan on a sandy coastal plain within

half a mile of the ocean. (Pl. II, figs. 1 and 2.) Jack beans (*Canavalia ensiformis*) and a few species of velvet beans (*Stizolobium* spp.) planted in April all made good growth; and as they crowded out all native weeds and grass, cultivation was dispensed with, except for cutting the leguminous vines near the palms every few weeks, until the plants died in the following winter. The Stizolobium species proved to have a longer growing season and to produce a heavier crop of vegetation than the Canavalia, and are, therefore, preferable in coconut plantations. The type of land suitable to coconut culture, if not cultivated, will, for most of the year, be overgrown with wild vines and weeds. These wild vines are almost as troublesome as the Stizolobiums in climbing over the young trees, and they store no nitrogen from the air and add much less vegetable matter to the soil. Coconut palms should be set farther apart than other orchard trees, and the cultivation of this large area and the improvement of the soil can be greatly facilitated by the judicious use of leguminous cover crops.

LEGUMINOUS COVER CROPS.

The experiments with leguminous cover crops and their value for planting with different crops have been continued and extended. A report on this work is being prepared for publication. Tests with a number of species were conducted in citrus orchards and pineapple plantings on heavy land and on sandy soil devoted to coconuts at Mayaguez and in citrus groves and coconut plantations on the north side of the island. Much of the work was with velvet-bean species, which have lately come into prominence as green manures in Porto Rico. The species under observation, aside from the well-known Florida velvet bean (*Stizolobium deeringianum*), are the Lyon bean (*S. niveum*), *S. aterrimum*, two varieties of *S. velutinum*, and *S. cinereum*. These crops have made an excellent growth in both heavy and light soils where rainfall has been sufficient. They are vigorous climbers, and when planted in citrus orchards or newly set coconut groves demand frequent cutting back to keep them from injuring the trees. They are ideal crops for "resting" land, as they keep down wild vegetation and greatly enrich the soil. As they live longer than cowpeas and make a heavier growth in sandy soil than either cowpeas or sword beans, they are more valuable for planting on coconut plantations. For reclaiming land or planting in groves as a cover crop or manure crop a choice of the species above mentioned may be made according to the length of season the planter wishes his field to be left uncultivated, for there is considerable difference in the length of growing season required for maturity of the different Stizolobiums, and their vining habits make cultivation impracticable.

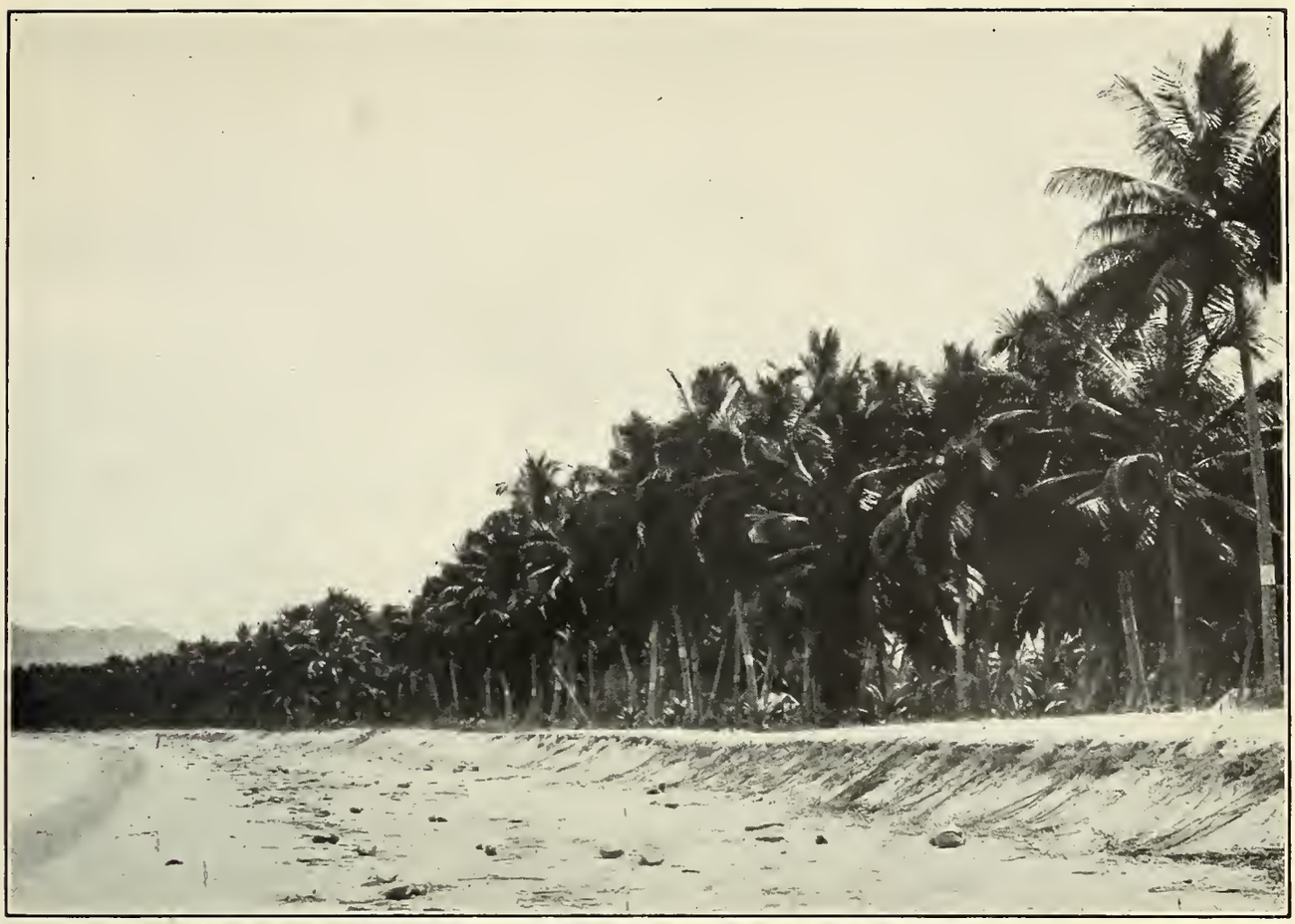

FIG. 1.—COCONUT PLANTATION, BOQUILLAS.

FIG. 2.—COCONUT FERTILIZER PLATS, BOQUILLAS.

The Florida velvet bean was the first of the Stizolobiums to be planted in a commercial way in Porto Rico. It requires the shortest season for growing to maturity of any of the velvet beans grown here, and has for that reason not been found as desirable for planting on pineapple or cane lands being reclaimed or among young coconut trees, where a heavy crop of vegetation is desired and where the expense of cultivation must be reduced to the minimum. Spring plantings of this crop on both heavy and light soils matured in about five months, and the drying vines were soon overgrown by wild vegetation. The Lyon bean, which produces a heavier vine crop and is a more vigorous climber, matured a month later than the Florida velvet bean. It is an excellent six-month crop. *S. aterrimum*, a species with black, shining seed, which has been distributed to many parts of Porto Rico, is still later in maturing than the kinds discussed above. It is one of the heaviest and most rampant growers tested here and the vines do not die until over eight months after planting. At 6 months and 20 days after planting the green weight of this species, including vines, leaves, and seed clusters, was 16 tons per acre. The dry weight after thoroughly sun drying was 4.3 tons. This species is one of the heaviest seeders. *S. cinereum*, while living somewhat longer than the last crop mentioned, is not as heavy a grower and is not a prolific seed producer. Two varieties of *S. velutinum*, one (S. P. I. No. 24424) which bears seed which are reddish gray marbled, with black in color, and the other (S. P. I. No. 24657) which bears gray seed marbled with black, have proved to have the longest growing season of any of the species tested here. They ripen at the same time and about three weeks later than other kinds. Variety No. 24657, which thus far seems to be the more rank grower of the two, produced a crop somewhat heavier than No. 24424. The late maturing kinds do not grow as rapidly at first as the common velvet bean or Lyon bean and do not cover the ground as quickly.

The experiments in growing leguminous cover crops and in testing the effect of shade trees on pineapples were concluded during the year. The results obtained did not differ materially from those reported in 1913. Both jack beans and pigeon peas were injurious to the two varieties of pineapples under observation—Cabezona and Red Spanish—when planted in the beds with them. The pigeon pea caused the most marked injury and the Cabezona variety was more severely injured than the Red Spanish.

The pineapple varieties just mentioned, with Egyptian Queen, Ruby, Black Jamaica, Trinidad, Smooth Cayenne, and Curaçao, were planted over two years ago in the area between 7-year-old *Pithecolobium saman* trees to test the effect of the shade and the

nitrogen stored in the soil by the leguminous trees on the development of the pineapples. The shade trees are growing 20 by 20 feet apart. Although the shade furnished by these young spreading trees was thin and the nodule growth on the roots very heavy, the pineapples were almost a complete failure. They suffered most during the dry winter months, when the trees no doubt robbed them of much of their required moisture. The conclusion reached in the work with growing leguminous crops with pineapples is that clean culture is necessary for the best development of pineapples.

Selections from a large number of legumes growing wild in Porto Rico are being tested to determine their value as cover crops. Many of these species are vigorous growers, have a long growing season, and have an advantage over many cultivated legumes of reseeding themselves.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The station has at one time and another imported many varieties of foreign coffee. Some of these come into bearing much later than Porto Rican coffee; some produce a larger, others a smaller, bean; some are of excellent quality and others inferior. Of these many types the planting of some is to be recommended and of others discouraged.

The planting of Mocha coffee on a commercial scale is not recommended. The quality is excellent, but the cherries are so small that the number contained in a given measure is nearly double that of Porto Rican coffee, and this alone would double the cost and difficulty of the picking.

As to vigorous growth and amount of yield, the Columnaris coffee is the most promising of the foreign coffees which have been tested on any scale and which have come into bearing up to the present time. It originated as a sport from the ordinary Arabian type and was discovered in Java less than 30 years ago. Its cup flavor is excellent. At four years from setting the yield of an extensive planting averaged about a pound per tree, and had the more favorably located trees only been considered, the rate would easily have been double this. The tree is more vigorous and grows taller than the typical Porto Rican coffee, and it may be necessary to resort to topping to facilitate picking. The bean is a trifle smaller than the Porto Rican, which is a slight market disadvantage.

The comparative sizes are shown by the 1,000-bean weight. One thousand normal, flat beans were selected from a very representative lot of market coffee—that is, coffee dried and with the parchment removed. These were then dried for more than five hours in an oven at about 105° C. The Porto Rican coffee after oven drying weighed 162.9 grams and the Columnaris 159 grams, while the Mocha weighed only 83.6 grams; or, expressed in percentages of Porto Rican weight, Columnaris equaled 97.6 per cent and Mocha 51.3 per cent. Samples of Padang coffee and Maragogipe ran larger than the Porto Rican, weighing, respectively, 116.9 per cent and 171 per cent.

Tests were also made of the comparative 100-bean weights of peaberry and flat bean. In samples of three varieties the peaberry ran

larger and in three others ran smaller than the flat bean, showing a very small average difference in weight.

The coffee-fertilizer experiments are continuing to show interesting results. In one experiment with more than a hundred trees the yield of the plat which had received complete chemical fertilizer and stable manure was more than 36 per cent greater than that of the check. Very interesting and valuable data are being accumulated, but as yet the experiments do not show that fertilizer can be applied with a financial gain. Further work should show whether or not one or more elements may be omitted and what quantities may be profitably applied. Work previously outlined is being continued and new plats have been laid off for fertilizer tests, which will help throw light on these questions.

It seems quite probable that coffee should be included among the acid-tolerant plants, as benefits from lime alone applied to the acid soils here at the station have been doubtful. In some instances there has been a very slight increase in height or yield over the check, while in one experiment the plat which made in the year the least growth of any was the one which had received the most lime, a little less than 2 tons. It is worthy of note that some of the handsomest coffee trees in the station plantings are in soil which is so acid as to require 1.0527 grams of sodium hydroxid for neutralization of 1 kilogram of soil.

Damage to the coffee by rats was reported from various sections of the coffee district. These depredations occur in the spring when there is an abundance of sap running. The preference is generally for the growth which should produce the coming crop, very little of the older wood being injured. Uprights from less than pencil thickness to half an inch in diameter are gnawed nearly through, the gnawing extending from a fraction of an inch to a foot or more along the stem. Some branches are bitten off entirely and others are left hanging. Frequently the lateral branches are broken so close to the upright that no buds are left from which other laterals may be produced. As the trees attacked are widely scattered, the cost of poisoned sprays is prohibitive and other means, such as dogs, traps, and poisoned bait, must be resorted to.

From a young coffee tree with some limbs bearing variegated foliage and others normally green leaves the seed were planted to watch the inheritance of variegation. Of 30 seedlings from limbs with variegated foliage 17 had variegated cotyledonous leaves and 2 more were slightly off color, while of 36 seedlings from limbs bearing normally colored leaves none were variegated. As the tree develops and more seed become available this study will be continued on a larger scale.

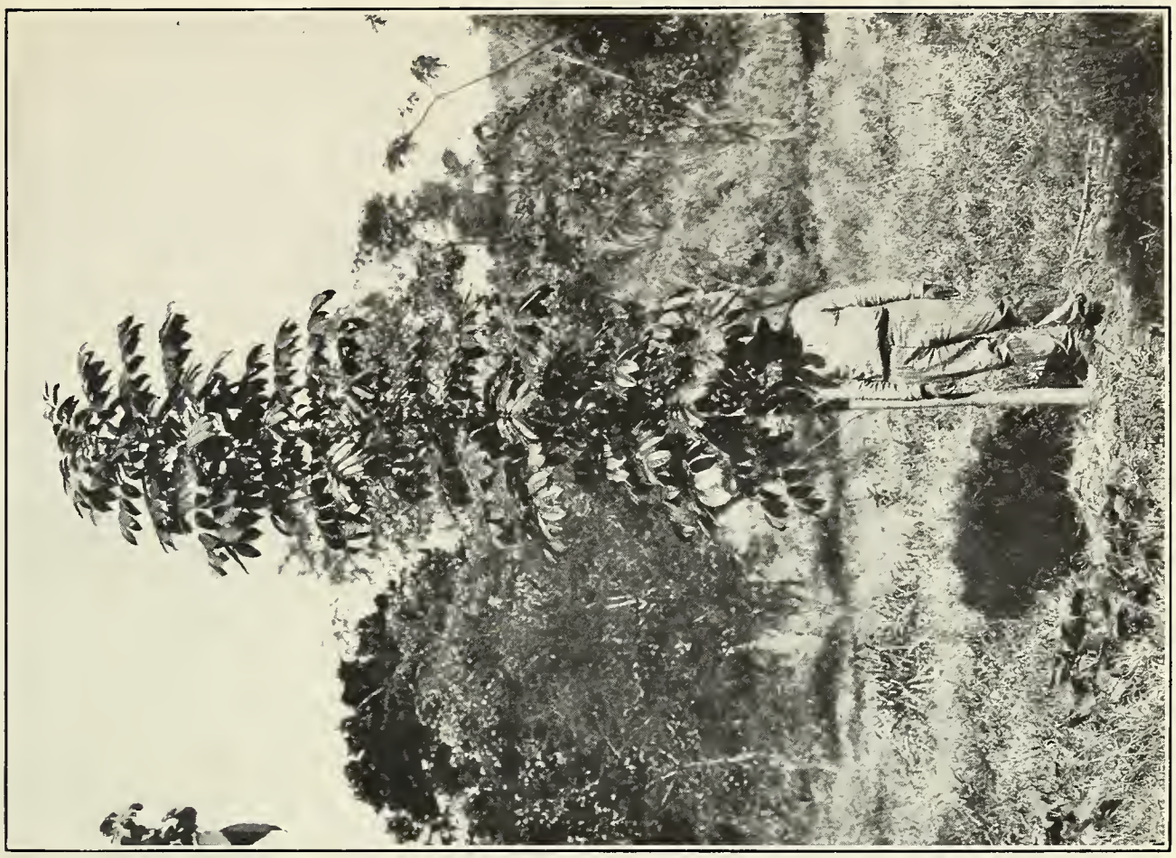

FIG. 2.—MAHOGANY TREE 2 YEARS OLD.

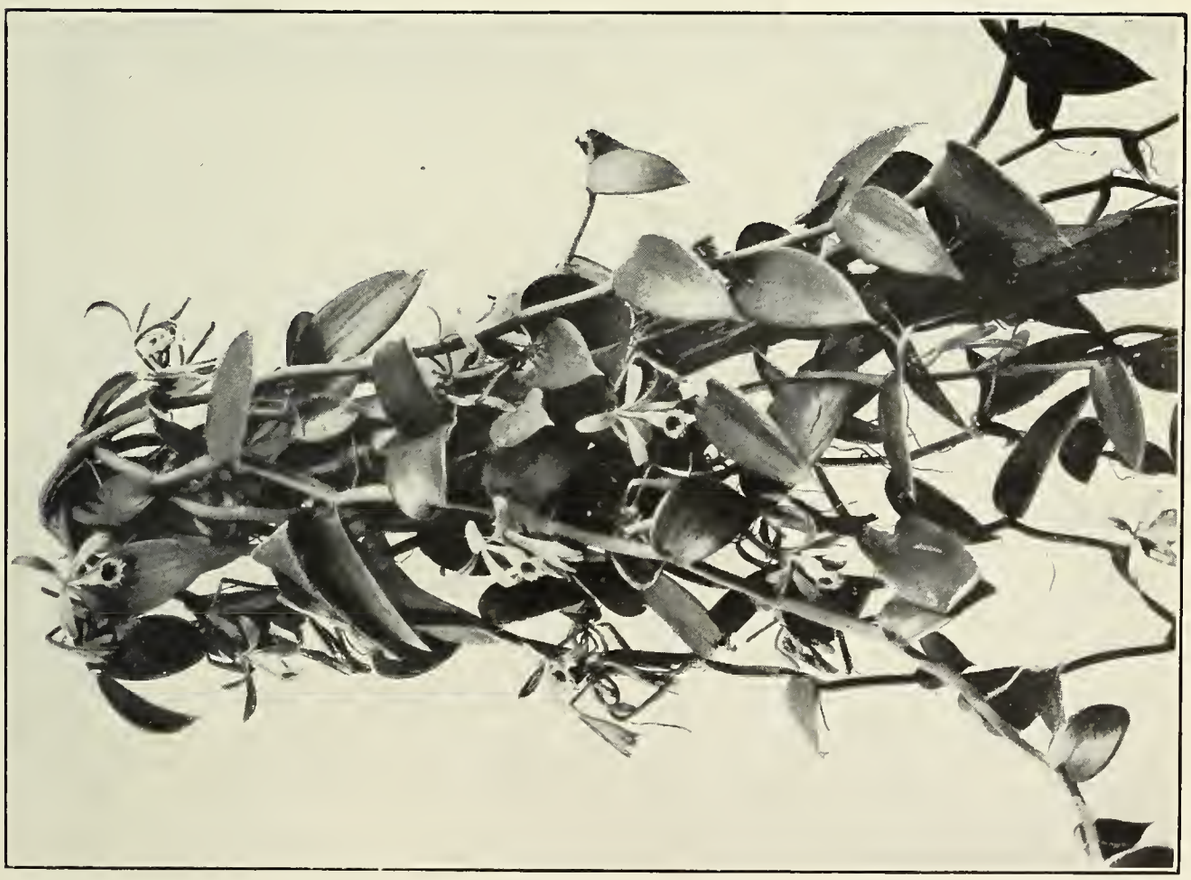

FIG. 1.—VANILLA IN FLOWER.

In cooperation with the college of agriculture, farmers' institutes for coffee planters were held in various towns in the coffee district, and such facts as had been brought out by the station's work and which the planters might find of value were presented.

As heretofore, very numerous requests for coffee seed were filled and some distribution of coffee plants was made.

CACAO.

The yield of the 11-year-old cacao planting has shown an increase of nearly a third over that of the preceding year, and was more than two and a half times as great as the crop of three years ago. The most productive tree yielded the equivalent of about 4 pounds of dried beans, worth 14 cents a pound. From weights of dried beans from more than 1,800 pods from the station plantings it was found that for a pound of unwashed dried beans an average of 11.13 pods were required. Exact data, lacking heretofore, on yields of such minor crops assume more importance, now that an interest in a more diversified agriculture has been stimulated by threatened reductions in the value of several staple crops.

VANILLA.

Of 19 cuttings of *Vanilla planifolia* started in 1912, two blossomed this spring. Most of the cuttings have made excellent growth and the vanillery is in a very promising condition.

Vanilla sp., "Pompon" (S. P. I. 14440), from Vera Cruz, Mexico, which has for four seasons shown itself sterile to all pollen from the same plant, was this season fertilized by pollen from *V. planifolia.*

Some of the vanilla species produce very handsome flowers, which, aside from all economic reasons, are well worth cultivating as ornamentals. One of the handsomest of these is a very thrifty Panama vanilla with large yellow blossoms. (See Pl. III, fig. 1.)

MISCELLANEOUS.

Monthly tappings of rubber are being continued, but the yields are so small as to discourage any plantings. The cost of tapping and collection alone has exceeded the value of the product.

Among plants of economic value obtained on a trip to Venezuela in 1913 several have shown themselves to be of unusual promise. A black bean, which is there a common staple but is not known here, is very vigorous and prolific. A very delicious table corn, which is something rarely found in Porto Rico, has shown itself fairly well adapted to some local soils. This corn, which is called "Cariaco,"

was said to be the best grown in Venezuela. Extensive plantings have been made of both the black bean and the corn to furnish seed for distribution.

Seedlings of mahogany, *Swietenia macrophylla*, have made exceedingly rapid and vigorous growth. One specimen at less than 17 months from seed measured 11 feet high (see Pl. III, fig. 2). There are many places accessible to roads which could be profitably planted with this valuable timber, which shows itself so well adapted to Porto Rican conditions.

The work with vegetables from seed brought from the north and grown in Porto Rico from one to many generations has been continued. Above everything else the marked effect of the planting season has stood out clearly. A tropical climate does not mean the ability to disregard the seasons.

REPORT OF THE PLANT PATHOLOGIST.

By G. L. Fawcett.

INTRODUCTION.

Various lines of work have been carried on during the past year, some of which are sufficiently complete to be mentioned in this report. Among these were the tests of the relative efficiency of the numerous ready-made preparations of Bordeaux mixture as compared with the freshly applied homemade mixture. These preparations are coming to be used quite extensively now that the grower has found that Bordeaux mixture can be used safely if applied with due regard to the weather conditions and the prevalence of scale. In making the tests coffee trees, some of which were infested with the surface-growing fungus of the leaf rot, were used, there being no citrus trees available. The sprays tested included the real Bordeaux mixture, a powder consisting of quicklime and copper sulphate, a Bordeaux paste prepared by one of the island planters, and a similar preparation from the States. These were used in equal concentration as nearly as could be estimated. The results, four weeks after the application, indicated that the fungus growth had been stopped in every instance, the fungus being apparently killed. With respect to fungicidal properties, as tested on this organism, there seems to be no difference in the value of the sprays. During the period of the test there had been but little rain. With more rain the results could well have been different, since the adhesive qualities differ markedly. This was shown by placing cacao leaves, which had been equally sprayed, under a spray of water for equal lengths of time. The ones on which the homemade preparation was used lost but little, those having received the freshly mixed powder being next best in this regard. The imported paste adhered less well than the others, being nearly all removed.

It is well known that fresh homemade Bordeaux mixture is somewhat different chemically and physically from the same preparation if allowed to stand some hours, when it becomes equivalent to the ready-made preparations. In these the division of the particles of the lime-and-copper salts is less fine, and they tend to adhere less well when applied in the spray. It is probable, however, that enough fungicidal properties are retained to control the fungi affecting citrus trees, as well as that of the coffee leaf rot, if not washed off too soon by rain and dew. One paste used to some extent by the growers but not tried in the tests seems to adhere very well. Possibly it contains some substance other than lime or copper to cause this.

The tests have shown nothing to indicate that the homemade preparation should not be used in place of these articles, since it is usually more efficient as well as cheaper.

COFFEE DISEASES.

Some tests were made as to the resistance of the foreign varieties of coffee to disease. *Stilbella flavida* was used first, inoculations being made at the same time on the leaves of *Coffea arabica* as checks. On the Robusta coffee (*C. laurentii*), especially well known because of its resistance to *Hemileia vastatrix*, it took readily, fruiting on the veins. On *C. liberica* and *C. abeokuta*, nearly related varieties, it has not taken well, the inoculation resulting in small wounds which healed over with suberized growth. The inoculation on *C. stenophylla* formed large spots which fruited freely. Those on *C. canephora* resulted in the formation of spots which fruited, but the fungus has not spread. On the checks *C. arabica* and on the closely related variety *C. arabica columnaris*, the fungus took readily, having spread to other trees. As *C. perieri* had already shown itself so subject to the disease, it was not used in the inoculations.

Little difference in the resistance to this fungus would be expected in these species of coffee, as it is capable of infecting and fruiting on plants belonging to widely separated families. Nevertheless, there seems to be decided differences. Even where it took well, as on *C. laurentii*, it acted much more slowly than on *C. arabica*. These differences are partly due, probably, to the fact that the habit of the trees with regard to distribution of the foliage varies, those species with large leaves, somewhat farther from each other, offering less favorable conditions than those with more numerous and closely set leaves, which renders distribution from leaf to leaf more easy and also tends to favor a stiller, more humid atmosphere. Another leaf character favoring the development of the spot is the closer venation. The spots develop noticeably better when in contact with a large vein and always fruit earlier when so situated. In some species, notably *C. abeokuta*, *C. liberica*, and *C. canophora*, the venation is not close. Other slight nonapparent differences in the chemical composition of the leaf may influence the result as to this point.

The inoculations with *Pellicularia koleroga* have taken well on the Robusta coffee, killing the leaves. Similar results have been obtained with those made on *C. stenophylla* and *C. abeokuta*. The Liberian coffee can hardly be expected to resist better than the *C. abeokuta*. *C. canephora* seems to take the fungus less readily. On the checks *C. arabica* and on the variety *columnaris* the infection resulted much sooner than on the other species. Whether the fungus will be able to establish itself permanently on these recently introduced trees as on the native coffee remains to be seen, but it is probable that it will

do so. A tree on which this does not happen in spite of infection would be really resistant.

No doubt the habit of growth, which favors the Stilbella, also favors this fungus. Where the pairs of leaves are close together it has smaller distances to pass along the stem between the sources of food supply. It is certain that most of the species worked with must possess some degree of resistance and are less easily infected than the native coffee. It is probably this quality which has enabled trees of *C. abeokuta* to remain free from the leaf rot, although surrounded by diseased trees.

It is improbable that these foreign coffees are so superior to the native coffee in both quantity and quality as to justify their being grown in place of that coffee. However, if a tree could be found even somewhat inferior from the standpoint of yield, its cultivation would be advisable in those places where the diseases are most prevalent. This applies especially to the "mancha de hierro." There is now no other practical solution of the problems presented by this disease and that due to *P. koleroga*. If such trees can not be found, or, if being found, they are not made use of, the conditions with respect to these diseases will remain as at present.

CACAO DISEASES.

A new fungus disease of cacao has been noted. The fungus is apparently a species of Corticium, but as no fruiting condition has been found and the vegetative characters are reported [1] to be different from those of *C. lilacino-fuscum*, no identification has been made. It covers the branches with a close pinkish growth which, when old, becomes white. It makes its first appearance at the lenticels of the branches, but only after it has attacked and killed the underlying tissues. It is extremely parasitic, differing in this also from the description of *C. lilacino-fuscum*. The attacked branches are invariably killed. In pure cultures, which may be obtained from the diseased tissue next to the still healthy material, it fails to take when inoculated into healthy tissue. In spite of this, its parasitism can hardly be doubted, since it occurs alone in the newly attacked tissue, and because its presence always marks the death of the branches. It also attacks and kills coffee-tree branches, and was found to be decidedly parasitic on grapefruit branches, although it has been found but twice on that tree. On coffee it is known only on a small group of trees in one plantation. The distribution of a fungus which on its known hosts is always sterile is of interest. It occurs usually on the branches, often well up in the tree and in well-located patches. The best explanation of its distribution is that it is typically a ground fungus, but ascends to the branches through the dead

[1] Dr. F. J. Seaver, New York Botanical Garden, in letter.

vines so common even in well-tended plantations. On the grapefruit it has been noticed connecting by mycelial growth the dead branches and an adhering vine. It is more probable that it passed from the vine to the tree than otherwise, since the diseased area did not extend far from the point of contact with the vine.

The control of the parasite will be found, no doubt, to be simple, consisting in the pruning out of the diseased material and the removal of all vines, dead as well as living, from the trees. Their presence, in any event, can not but result in injury to the trees.

A disease of cacao very troublesome in most countries is the canker now generally conceded to be caused by the Phytophthora that causes the black rot of the pods. In Porto Rico the writer has found no really injurious disease of this nature, although occasionally there are to be found wounds on the trees which answer closely to those described for the real canker, the discoloration of tissue and exudation being apparently the same in both diseases. It is probable, however, that the symptoms could be the same even if the trunk were attacked by very different organisms. In Porto Rico *Phytophthora faberi* has never been found in this or other cacao material, but *Spicaria* (*Fusarium*) *colorans* is always to be isolated from the diseased tissues. Inoculations with pure cultures of the fungus do not take, the wounds healing vigorously under the material used in the inoculation. To produce a canker wound it seems clear that some severe wound or the continued attacks of insects, such as the common borer, is necessary. The Spicaria may take some part in the production of the trouble, but, so far as the Porto Rican canker is concerned, it is practically a question of avoiding the insects or of the breaking of the trees caused by the fall of palm leaves. The wounds so made apparently enable the somewhat parasitic fungus to get well started; healing is retarded and a canker is observed long after it has become impossible to say what the real cause of the trouble may have been.

DISEASES OF CITRUS TREES.

The disease of these trees given most attention was the black rot of the fruit (*Diplodia natalensis*), which causes notable losses to the fruit in shipment. The fungus has been found to fruit only on the branches, where it causes a dying back under certain conditions. The fruit has been found to be infected in the groves before being picked, and the fungus spreads but little from diseased to healthy fruit in the packed boxes. Sufficient data were obtained to indicate a rational method for its control. The principal results of this work have appeared in a local publication.[1]

Work has been done with the diseases of banana and other fruits, the results of which will be given in separate reports.

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[1] Porto Rico Progress, 8 (1914), pp. 5, 7.

REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg

INTRODUCTION.

Between the date of the death of the former entomologist, Dr. Charles W. Hooker, February 12, 1913, and October 16, 1913, the only work carried on in this department was with honeybees. The entomological collection has been materially increased and the very comprehensive note system begun by Dr. Hooker has been maintained. Much of the recorded work on hand in October had to do with life histories and habits of important insect pests, and some of it had already been well advanced. All of this work will be continued as steadily as possible.

As usual the most troublesome pests on the island have been the changa, shot-hole borers, and ants, and no important advance in methods of control of these insects has been made. May beetles and the sugar-cane root and stalk borers have been as important as ever in the cane district. In the Mayaguez section there have been outbreaks of the chiva (*Megalopyge krugii*), damaging guamá and coffee foliage; of the common cucumber beetles, *Diabrotica innuba* and the smaller, *D. bivittata;* and of shot-hole borers (probably *Xyleborus* sp.), which have killed numbers of guamá trees (*Inga laurina*). During the winter months the diamond-back moth (*Plutella maculipennis*) did some damage to cabbage, but was reduced to unimportance when the heavy rains began. There was a local outbreak of *Melanchroia cephise* in Camuy, where the larvæ practically stripped the grosella trees (*Phyllanthus distichus*). A round-headed borer (*Apate francisca*) is very numerous about Mayaguez and has 10 recorded host plants. It has been taken in living *Salix humboldtiana* and in dry posts of palo de hueso (*Picramnia pentandra*).

The principal work of the past year has been with the pests of coffee and coffee shade trees, with miscellaneous insect enemies, and with a bacterium pathogenic to May-beetle larvæ. A preliminary check list of Porto Rican insects has been prepared for the use of working entomologists on the island.

THE CHANGA.

Many remedial measures for the control of *Scapteriscus didactylus* have been tested at the station. Of these, one gives promise of satisfactory results. This is the strewing broadcast over infested

areas of "funche," the phosphorus and corn-meal mixture used on cane plantations against land crabs. Although remarkable results have not been obtained with this method in Mayaguez, it is said to be very effective on an estate on the south coast. Needless to say, this remedy is dangerous in the presence of poultry.

The life history of the changa is at present being worked out in detail, and it is expected that something of value concerning this pest can be offered later.

COFFEE LEAF MINER.

The coffee leaf miner (*Leucoptera coffeella*) is abundant in all the coffee-growing sections of the island, and, although never causing the death of even young trees, it makes a heavy drain upon the vigor of the plants. Coffee is the only known host plant of this insect. The pest is in all probability a native of the West Indies, whence it has spread to the South American mainland.

The adult is a minute silvery white moth measuring about $2\frac{1}{2}$ millimeters when its wings are closed. The outer margins of the wings bear yellow hairs, which give a dirty yellow appearance to the end of the body when the insect is at rest. The moth usually rests on the underside of leaves and is easily disturbed, moving with a swift, jerky flight. In the laboratory adults have been kept alive four days.

The eggs of the leaf miner are laid singly and unprotected on the upper surface of the coffee leaf. The egg is oval and pearly white; it measures about 0.33 millimeter long and 0.25 millimeter wide. The sides of the egg slope upward sharply and the greater part of the surface is occupied by a boat-shaped depression. The egg stage averages slightly less than five days in the winter months, although during April it is four days, according to Dr. Hooker. The young larva makes its way through the base of the egg directly into the leaf tissue, where it begins to feed almost at once. The eggs are most commonly placed beside or near a vein of the leaf, but may be found on any part of the upper leaf surface except very near the tip or base. The number of eggs laid by a single female is not known.

The larva passes all its time within the mine and in from 11 to 13 days, when full grown, it is between 4 and 5 millimeters in length. The body is dorso-ventrally flattened and tapers from the head backward, with a slight increase in width at the first three abdominal segments. Normally there is one larva in a mine, but when the feeding galleries cross and merge as many as seven larvæ have been found together.

When the larva is full grown it makes a small slit in the upper surface and crawls to the underside of the leaf to pupate. The

pupa case is about 5 millimeters long and is made of a white silk secreted by the larva. A few hours after spinning up the pupa is formed within its case and the adult emerges in six to eight days.

The Liberian coffee seems to be free from serious attack by the leaf miner. The eggs are laid on its leaves commonly enough, but after feeding a day or two, making a very small mine, the larva dies, due either to the toughness of the leaf tissue or to the absence of proper food. In many cases the larvæ are unable to gain entrance into the leaf from the egg. The mines in Liberian coffee have a peculiar embossed appearance quite unlike the normal flat mine in the leaves of Arabian coffee.

The coffee leaf miner in the larval stage is parasitized by two chalcid flies, *Chrysocharis livida* and *Zagrammosoma multilineata*, the former being especially abundant in the Mayaguez district. During the spring fully 30 per cent of several hundred occupied mines inspected in the station coffee planting contained pupæ of *C. livida*.

Spraying infested trees with one pint of nicotin sulphate in 100 gallons of water containing 5 pounds of soap in solution is effective against the pupæ if applied with considerable force to the undersides of the leaves, but the results will not repay the expense and labor involved. Any mechanical treatment will be impractical in a commercial coffee planting where the unevenness of the land makes work slow and expense high. A similar mixture with 29 fluid ounces of nicotin sulphate in 100 gallons of soap solution gave no practical results. Less than 15 per cent of the larvæ in the mines succumbed and the eggs were unaffected.

Anything, such as cultivation, for example, which will render the coffee trees more vigorous will help them to offset the attacks of the insect with strong and healthy growth.

COFFEE SHADE PESTS.

The most troublesome insect of coffee shade trees during the past year has been the shot-hole borer (probably *Xyleborus* sp.) working in guamá and guava (*Inga laurina* and *Inga vera*, respectively). These two trees are the favorites for shading plantations of coffee; the only point against them seems to be their susceptibility to insect attack. In some of the hill districts whole areas of guamá are killed by the shot-hole borers, and the coffee beneath exposed to the direct rays of the sun. The control of the insect, therefore, is a serious problem for the coffee growers. As far as the writer knows, infested trees recover only occasionally, and then only from very light attacks; it is, therefore, important to stamp out the insect at its earliest appearance. Trees should be felled and converted into charcoal as soon as the beetle is found to be present.

The undetermined pink Coccus attended by *Myrmelachista ambigua ramulorum* on the branches of guamá is very troublesome, and when it spreads to coffee it becomes one of the worst pests of that crop, due to the weakening of the branches and the destruction of new growth. The removal of all the infested branches from isolated trees at the station a few years ago has been a success, although a close inspection of the trees is necessary from time to time. Banding trees with Tanglefoot, offering poisoned baits, and similar remedies have been unsuccessful in ridding trees of the attending ant.

The larva of a "flannel moth," *Megalopyge krugii*, known locally as the chiva, has been very abundant on guamá, causing considerable damage to the leaves. Occasionally coffee is also attacked, especially the Liberian variety. The larva is covered with long white hairs and is provided with brittle spines which cause a burning sensation if allowed to come in contact with the skin. The pupa case is a very common sight on the trunks of guamá; it is oval, with a "trap-door" exit at one end. The very tough case measures 16 by 10 millimeters and is formed of the hairs of the larvæ mixed with a substance secreted by the mature larva. The chiva is very commonly parasitized by an undetermined tachinid fly and by *Chalcis ovata*. The latter is very abundant at times, and it undoubtedly serves as an important check on this pest.

MAY BEETLE.

During the past year some work was done with a bacterium pathogenic to Lachnosterna larvæ. This bacterium has been described as *Micrococcus nigrofasciens*. The results obtained here with cultures of this bacterium were unsatisfactory, for the larvæ in check cages showed almost as high a percentage of mortality as those in the inoculated cages. However, it developed later that the bacterium is native to Porto Rican soils and is apparently widespread. The disease in Lachnosterna is confined to the larval stages, and is characterized by a blackening of the parts affected. The organism is present in our soils, but its efficiency can not be increased by any practical means, for infection takes place usually only through a bruise or cut in the integument of the larva.

MISCELLANEOUS PESTS.

The brown "woolly bear" caterpillar (*Ecpantheria eridanus*) was fairly common on orange trees in the Mayaguez district. The spherical lemon-yellow eggs are laid on the leaves in an irregular mass, containing 500 or more and hatch in 6 to 8 days. The larvæ are voracious feeders and come to maturity in about 5 weeks after hatching. Pupation takes place in a loose web of brown silk and requires about

17 days. In addition to the orange, the larvæ feed on the leaves of banana, bucare, and sweet potato.

The small sweet-potato weevil (*Euscepes* (*Cryptorhynchus*) *batatæ*) made its appearance in the station planting during the winter months. This insect prefers a dry, light soil, and will then increase rapidly. Sweet potatoes should not be left in the ground after they are full grown, but should be gathered as soon as possible. Neither should they be planted in soil which was infested the season before.

Silk oak trees (*Grevillea robusta*) are often severely attacked by the fringed scale (*Asterolecanium pustulans*). This is a sulphur-yellow scale which forms pitlike depressions on the twigs and small branches; it is common throughout the island. A lime-sulphur spray repeated after two weeks will control this insect.

Some damage to tobacco seed pods by the boll or false bud worm (*Heliothis obsoleta*) was noticed in plantings at the station. Corn is the preferred food plant of this insect, but tobacco and tomatoes are attacked also as the corn comes to maturity. If otherwise possible, tobacco should not be planted near fields of corn. Seed pods may be protected by bagging with light cloth. This insect also attacks the tobacco buds and may then be controlled by sprinkling an arsenate of lead and cornmeal mixture on or into the buds.

The most common large weevil of the island and at the same time one of the most important is *Diaprepes spengleri*. This is the snout-beetle, called the "orange leaf weevil" by the citrus growers and the "weevil root borer" by the cane planters. The adult has a great variety of host plants and the larvæ have been reared on the roots of cane, orange, and sweet potato. On citrus trees the eggs are laid in groups of 20 to 150 on the upper leaf surface and are protected by gluing another leaf over the cluster or by fastening over a portion of the same leaf. The eggs are white and cylindrical in form; they measure about 1 millimeter in length and 0.33 millimeter in breadth. Upon hatching, the young drop from the leaf and enter the ground, where the rest of their development takes place. The attacks of the adult are not often serious, but in case they do become so on citrus trees, they may be controlled by arsenical sprays.

HONEYBEES.

In an effort to improve the strain in the station's apiary all crossed queens have been replaced by tested Italians, most of them imported. The sale of nuclei has been discontinued. There are now several queen breeders in the island, and it no longer is necessary for the station to provide beekeepers with nuclei.